Exemption No. 7933

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
RENTON, WASHINGTON 98055-4056

In the matter of the petition of **Embraer Empresa Brasileira de Aeronáutica S.A. (Embraer)** for an exemption from § 25.901(c) of Title 14, Code of Federal Regulations	**Regulatory Docket No.FAA-2002-13021**

GRANT OF EXEMPTION

By letter dated August 2, 2002, Mr. Paulo C. Olenscki, Certification Manager, Embraer Empresa Brasileira de Aeronáutica S.A. (Embraer), Av. Brigadeiro Faria Lima, 2170, 12227-901 – S. José dos Campos – SP, Brazil, petitioned for an exemption from the "no single failure" criteria of § 25.901(c) of Title 14, Code of Federal Regulations (14 CFR) as it relates to "uncontrollable high thrust failure conditions." Recent studies and service experience indicate that some existing transport category airplanes do not strictly comply with § 25.901(c) for certain uncontrollable high thrust failure conditions. The proposed exemption, if granted, would permit type certification of similarly non-compliant Embraer Model EMB-135BJ series airplanes to allow installation of Rolls-Royce (RR) AE 3007A1E series engines, and subsequent RR AE 3007A series engines.

The petitioner requires relief from the following regulation(s):

> Section 25.901(c) requires in part that "no single failure will jeopardize the safe operation of the airplane."

The petitioner's supportive information follows:

> The EMB-135BJ fully complies for all uncontrollable high thrust failures while in flight. On-ground high thrust failures followed by overspeed trip protection are also controllable. Simulator assessment has shown that the exposure envelope for a catastrophic event from an uncontrolled high thrust is limited to the ground portion of a landing scenario and

take-off abort scenarios. The exposure to a catastrophic event is limited to 20 seconds per flight cycle. This inflight and ground portion assessment was confirmed by the Centro Tecnico Aeroespacial (CTA).

The engine control system for the RR AE 3007 engine family installed on the EMB-135BJ airplane is the same system that is currently used on the EMB-145 family of airplanes. The control system architecture (means and logic for controlling the engine) remains unchanged. Minor changes have been incorporated into the system to allow the engine thrust to be increased to 8,716 lbs. (7%). The changes include a modified fuel pump and metering unit (FPMU) to allow a higher fuel flow, new A1E thrust rating modes, and minor changes in terms of full authority digital electronic control (FADEC) hardware. The modified FPMU will be certified for use on all EMB-145 family airplanes. A larger teeth gear pump within the FPMU provides the higher fuel flow required for the A1E higher thrust.

The cockpit engine control means, identical to those that presently exist in the in-service fleet, are retained. Those means are: the thrust lever angle (TLA) for modulating thrust, the start/run/stop switch for starting or shutdown of the engine, and the fire handle used to cut the fuel off in the fuel line before the FPMU shutoff valve. Should a pilot lose the normal means to control thrust through the TLA, the start/run/stop switch or fire handle is still available to shut down the engine if it is operating erratically or producing more than commanded thrust.

The EMB-145 family of airplanes powered by the RR AE 3007 engine has demonstrated an excellent in-service safety record. Embraer has delivered about 600 aircraft and the fleet has accumulated over 2.5 million flight hours of revenue service. There were three events of thrust control malfunction that led to higher-than-commanded thrust. Two events occurred in flight and one on the ground, and none of them impacted the safety of operation. In the first event the aircraft experienced an N1 overspeed and uncommanded inflight shutdown (IFSD) while on approach due to an improper main metering valve (MMV) fault accommodation in the FADEC software. In response to the software deficiency, a new FADEC version (VI.2) was built in order to avoid this thrust control malfunction. The solution is already implemented for all the fleet and has eliminated this situation as a potential failure.

In the second event, the aircraft experienced a rejected takeoff due to coil separation in the MMV servo valve. The crew was able to control the airplane on the runway. Rolls-Royce investigation revealed that the failure originated from a manufacturing deficiency and only the valves manufactured between January 1998 and August 1998 were affected. All suspected units have been removed as of August 31, 2002. The cause of this malfunction was found to be improper cleaning of the housing, which reduced adhesion of the torque motors' coils. To avoid this problem caused by quality problems, the MMV servo valve supplier implemented an improved assembly process (since July 2000) in order to prevent the possibility of the coil dislodging and vibrating, releasing debris into the torque motor. None of the FPMU, which went through overhaul inspections after

this modification, have presented any malfunction, demonstrating the effectiveness of the new process. The third thrust control malfunction event is still under investigation.

Considering that two of three uncontrolled high thrust occurrences have had the failure mode eliminated by design changes implemented in the fleet and an effective improved assembly process of the FPMU, and the EMB-145 family of airplanes has accumulated over 2.5 million flight hours revenue service, the average rate for this failure mode based on service history is a probability compatible with the existing safety level in turbofan-powered aircraft in the worldwide fleet.

The service probability prediction accounts for failures in which the thrust is increased and held high and also for the failures in which the engine is accelerated and subsequently shut down due to the overspeed protection. As mentioned in the analytical probability section, the engine acceleration followed by an engine shutdown is not critical for the EMB-135BJ configuration (refer to the simulator testing). Given that the only remaining failure experienced in the fleet caused an uncommanded engine shutdown, it is expected that the probability of an uncontrolled high thrust where the engine thrust is held high will be less than that in which the engine is subsequently shut down due to overspeed protection.

The petitioner agrees to demonstrate that:

"…all practicable actions have been taken to minimize the adverse effect on safety associated with granting of the exemption from 14CFR 25.901(c) for the EMB-135BJ/RR AE 3007A1E series engines."

"…the risks associated with granting of the exemption from 14CFR 25.901(c) for the EMB-135BJ/RR AE 3007A1E series engines are low…."

Specifically, Embraer will demonstrate the following:

"The EMB-135BJ/RR AE 3007A1E complies with 14CFR 25.901(c) for any foreseeable uncontrollable high thrust failure conditions in flight and on the ground, except during takeoff and landing touchdown; and

"The frequency of occurrence of uncontrollable high thrust failure condition on the EMB-135BJ/RR AE 3007A1E fleet will be less than one per ten million airplane operating hours."

Waiver of notice and public procedure:

The FAA has determined that good cause exists why action on this petition should not be delayed by publication and comment procedures for the following reasons: The petitioner's request does not set a precedent, because the relief request is identical to exemptions granted previously, and a

delay in acting on the petition caused by publication might have an adverse effect on the operator of the airplanes, who has made substantial plans for the introduction of the airplanes into their fleet.

The Federal Aviation Administration's (FAA) analysis is as follows:

Background

Uncontrollable High Thrust Failure Conditions

Numerous single and anticipated combinations of failures within traditional turbojet engine control systems result in losing the normal means to control thrust (i.e., control via the throttle lever, autothrottle, etc.). A subset of the resulting failure conditions may include actual thrust either increasing to higher than commanded levels and/or remaining high when low thrust is commanded. These "uncontrollable high thrust failure conditions," and the hazards they pose, have long been inherent in transport airplane designs. In fact, the "fail-safe" states for engine controls have traditionally been chosen to protect high thrust capability and allow the flightcrew to decide when an engine shutdown is appropriate.

An initial estimate indicates that over the last 20 years the average rate of occurrence for the uncontrollable high thrust failure condition on turbofan-powered large transport category airplanes has remained relatively constant at around one every 2.5 million flight hours. This would indicate that to date an "uncontrollable high thrust failure condition" has occurred hundreds of times without resulting in a single reported serious injury.

When these failure conditions were identified during past certifications, compliance was typically based on accepting an assertion that the flightcrew will recognize and safely accommodate the loss of the normal means to control engine thrust, including shutting down the affected engine via an independent fuel shutoff as required. However, recent engineering studies and service experience, including a 1997 Saudi Arabian Airlines Boeing 737-200 accident, indicate this traditionally accepted assertion is not always valid. For those airplanes re-evaluated to date, the available failure recognition and accomodation time under certain anticipated operating conditions is so short and the required corrective actions sufficiently unnatural that the flightcrew cannot be relied upon to reliably and completely perform those actions before the safe operation of the airplane is jeopardized.

The FAA is responding to this revelation by developing a "Thrust Control Malfunction Airworthiness Program" to consistently and objectively assess and manage the existing and future transport airplane fleet risks associated with this endemic potential for non-compliance and unsafe conditions. The ultimate goals of this program will be to bring the transport airplane fleet back into compliance as quickly as practicable, while ensuring that the risks associated with interim non-compliances are managed so that they do not represent unsafe conditions.

In the interim, for type certification the FAA has begun requesting more effective validation of any assertion that the flightcrew will recognize and safely accommodate the loss of the normal means to control engine thrust. Such a request is what led to the subject petition and is likely to lead to many more such petitions until practicable design solutions can be identified, validated, and safely integrated into turbine engine control system type designs.

Embraer Model EMB-135BJ Series Airplanes and RR AE 3007A1E Series Engines

The engine thrust control system for the Rolls Royce AE 3007A1E engine family proposed to be installed on the Model EMB-135BJ series airplane is the same system that is currently approved on the EMB-135 airplane family. However, the petitioner has indicated that there are single failures on the ground during takeoff and landing touchdown that can cause a RR AE 3007A1E series engine to produce high thrust, up to the level where the first independent limiter (governor) is encountered, while not responding to the throttle lever. Further, the petitioner has indicated that this may jeopardize the safe operation of the Model EMB-135BJ airplane if it occurs during some particular takeoff or landing conditions.

The petitioner intends to demonstrate that any combinations of failures that could jeopardize safe operation comply with § 25.901(c) in that they are not "probable combinations." (Note: the term "probable," as used in § 25.901(c), means "foreseeable," "anticipated to occur," or "not extremely improbable" and hence has a very different meaning than the same term as subsequently used in association with § 25.1309(b) compliance.) Conversely, the petitioner does not intend to demonstrate that those single failures that could jeopardize safe operation comply with § 25.901(c). Compliance with § 25.901(c) requires that each identified single failure be assumed to occur under all anticipated combinations of airplane operating and environmental conditions. While the single failures themselves must be assumed to occur regardless of their probability, probability can be considered when determining what combinations of operating and environmental conditions are anticipated to occur in the fleet life of the airplane type. Single failures do not need to be assumed to occur under conditions that are in and of themselves not expected to occur. Nonetheless, the proposed design is known to have single failures that will cause uncontrollable high thrust.

Uncontrollable high thrust under certain anticipated takeoff and landing touchdown conditions is expected to jeopardize the safe operation of the proposed airplane. Consequently, in order to certificate the installation of the RR AE 3007A1E series engines on the Model EMB-135BJ series airplanes, the petitioner must either obtain this exemption or substantially modify the associated engine control system design to mitigate the noted failure conditions on the ground. As delineated in the petitioner's supporting information, the petitioner has concluded that the exemption is the option which best serves the public interest.

FAA Analysis - Introduction

To obtain this exemption, the petitioner must show, as required by § 11.81(d), that granting the request is in the public interest, and, as required by § 11.81(e), that the exemption will not adversely affect safety, or that a level of safety will be provided that is equal to that provided by the rules from which the exemption is sought.

FAA Analysis - Public Interest

The petitioner has commited to demonstrate that all practicable actions have been taken to minimize the adverse effect on safety associated with granting of the exemption from § 25.901(c) for the Model EMB-135BJ series airplanes with RR AE 3007A1E series engines. If the FAA is to certify the EMB-135BJ/RR AE 3007A1E airplanes, making this commitment a condition of the exemption assures that granting the exemption will prove to be in the public interest. That is, any risks associated with a known non-compliance must be eliminated or further reduced wherever the FAA finds that to do so is technologically feasible and cost beneficial for the public. This has traditionally been accepted as the level of safety that is "in the public interest." Furthermore, if bringing the airplane into compliance is found to be a "practicable action," then this exemption would in effect be self eliminating.

In consideration of the above, the FAA concludes that granting this petition is in the public interest.

FAA Analysis - Effect on Safety

The petitioner has commited to demonstrate that the EMB-135BJ/RR AE 3007A1E airplanes' exposures and failure rates are such that this airplane should not exceed the known average per flight hour risks of comparable existing transport category airplanes. Making this commitment a condition of this exemption, in combination with the condition to minimize that risk, means that granting this exemption should not adversely affect and, in fact, should improve the average per flight hour risk within the current transport airplane fleet.

For those existing transport airplanes re-evaluated to date, the conditions under which an uncontrollable high thrust failure may jeopardize the safe operation of the airplane are limited to specific aborted takeoff or approach and landing scenerios. Given that these scenarios occur, there is still a low probablity that any serious injury will result. This limited exposure, in conjunction with the historically low occurrence rates, make this a relatively low per flight hour risk. This assessment is supported by the fact that the 1997 Saudi Arabian Airlines Boeing 737-200 accident is the only one attributed to these types of failures and there were no serious injuries in that accident.

It is the spectre of this low per flight hour risk accumulating indefinitely on many, if not most, existing and future transport airplanes that is the primary concern driving

development of the FAA "Thrust Control Malfunction Airworthiness Program." To date, corrective actions under 14 CFR part 39 have only been considered warranted when the uncorrected risks for a particular type design were considered significantly greater than the known average risks within the transport fleet. Since the conditions and limitations of this exemption require that the Embraer Model EMB-135BJ series airplane with RR AE 3007A1E engine be expected to have an uncontrollable high thrust failure rate over three times better than the current fleet average, the impact of adding the fleet hours of the Model EMB-135BJ series airplane with RR AE 3007A1E engine to the overall transport fleet exposure should be insignificant. Furthermore, if as part of the "Thrust Control Malfunction Airworthiness Program," the FAA determines that additional generally applicable precautions must be taken, including perhaps some future introduction of a compliant design, these will further minimize any cumulative risk impact of granting this exemption.

This exemption inherently implies a somewhat greater hazard than full compliance with § 25.901(c). This is why the FAA intends to bring the transport fleet back into full compliance as soon as practicable. Nevertheless, the fact that the per flight hour risks associated with this non-compliance are low allows us to develop a well considered recovery program to assure we don't introduce a worse problem than we are trying to solve and that this recovery program is clearly in the public interest.

In consideration of the above, the FAA concludes that granting this petition will not adversely affect safety.

Conclusion

In consideration of the foregoing, I find that a grant of exemption is in the public interest and will not adversely affect safety. Therefore, pursuant to the authority contained in 49 U.S.C. 40113 and 44701, delegated to me by the Administrator, Embraer Empresa Brasileira de Aeronáutica S.A. (Embraer) is granted an exemption from § 25.901(c) to the extent necessary to allow type certification of the Model EMB-135BJ series airplanes with RR AE 3007A1E series engines and subsequent RR AE 3007A series engines without an exact showing of compliance with the requirements of § 25.901(c) as they relate to single failures resulting in uncontrollable high thrust conditions. For the Model EMB-135BJ series airplanes this exemption is subject to the following conditions and limitations:

1. Embraer must demonstrate, in accordance with an FAA-approved "Airworthiness Assessment and Risk Management Plan," that all practicable actions have been taken to minimize the adverse effects on safety associated with granting this petition. These must include, but are not limited to, practical actions to eliminate or further reduce the risks by improving designs, procedures, training and instructions for continued airworthiness.

2. Embraer must demonstrate, in accordance with an FAA-approved "Airworthiness Assessment and Risk Management Plan," that the risks associated with exempting the "uncontrollable high thrust failure condition" from the single

failure provisions of § 25.901(c) are no greater for the proposed Model EMB-135BJ series airplanes with RR AE 3007A1E series engines than those generally known to exist for comparable airplanes within the current transport fleet. Acceptable risk for this provision can be characterized as:

a. The airplane complies with § 25.901(c) for any foreseeable uncontrollable high thrust failure conditions in flight and on the ground, except possibly during takeoff and landing touchdown; and

b. The expected frequency of occurrence of the uncontrollable high thrust failure condition is less than once per ten million airplane operating hours.

3. The following "Note" will be added to the airplane Type Certification Data Sheet for any airplane certificated under this exemption:

The FAA has concluded that the occurrence of any uncontrollable high thrust failure condition, or any of the associated causal failures listed within Embraer Document (reference tbd) are reportable under §§ 121.703 (c), 125.409 (c), and 135.415(c).

In support of this "Note," Embraer must develop and obtain FAA approval of the Embraer document referenced in the "Note," prior to customer delivery. This document lists those failures that can contribute to or cause an uncontrollable high thrust failure condition covered by this exemption. This document shall then be made available as part of the instructions for continued airworthiness. Further, the failures listed within this document shall be added to the list of reportables under § 21.3 for any airplane certificated under this exemption.

4. The granting of this exemption does not relieve any regulatory obligation to identify and correct unsafe conditions related to uncontrollable high thrust failure conditions.

Note: Additional background and guidance regarding these provisions are provided in FAA Letter 02-112-02, dated October 19, 2001.

Issued in Renton Washington on December 12, 2002.

/s/ Ali Bahrami
Ali Bahrami
Acting Manager
Transport Airplane Directorate,
Aircraft Certification Service